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Talbot et al.

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(54) **APPARATUS FOR FABRICATING NEEDLES VIA CONFORMAL DEPOSITION IN TWO-PIECE MOLDS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/454,823**

(22) Filed: **Dec. 6, 1999**

Related U.S. Application Data

(62) Division of application No. 09/044,398, filed on Mar. 18, 1998, now Pat. No. 6,106,751.

(51) **Int. Cl.**^{7} **B22D 23/00**

(52) **U.S. Cl.** **249/105**; 249/135; 164/46

(58) **Field of Search** 249/105, 160, 249/135, 107; 425/470, 403, 462, 463, 570, 573; 164/46

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Assistant Examiner—Thu Khanh T. Nguyen
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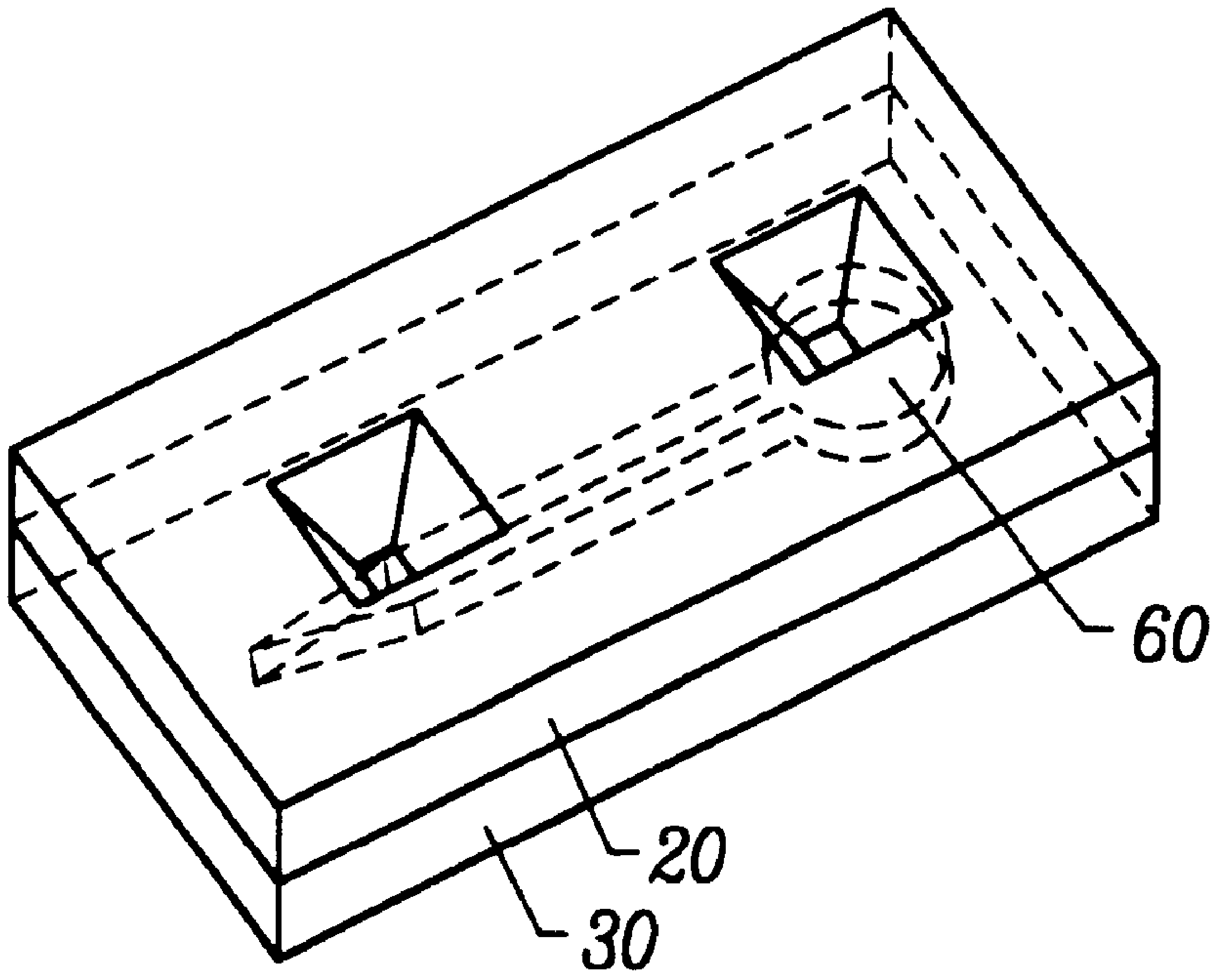
(57) **ABSTRACT**

A method of fabricating a needle via conformal deposition in a two-piece mold includes the step of attaching a top mold member to a bottom mold member such that the top mold member and the bottom mold member define an enclosed, elongated needle trench with a deposition aperture. A conformal substance, such as polysilicon, is then passed through the deposition aperture such that the conformal substance is deposited within the enclosed, elongated needle trench to form a needle. The method is used to form needles with prongs, multiple channels, multiple ports, barbs, strength enhancement features, and circuitry.

10 Claims, 8 Drawing Sheets



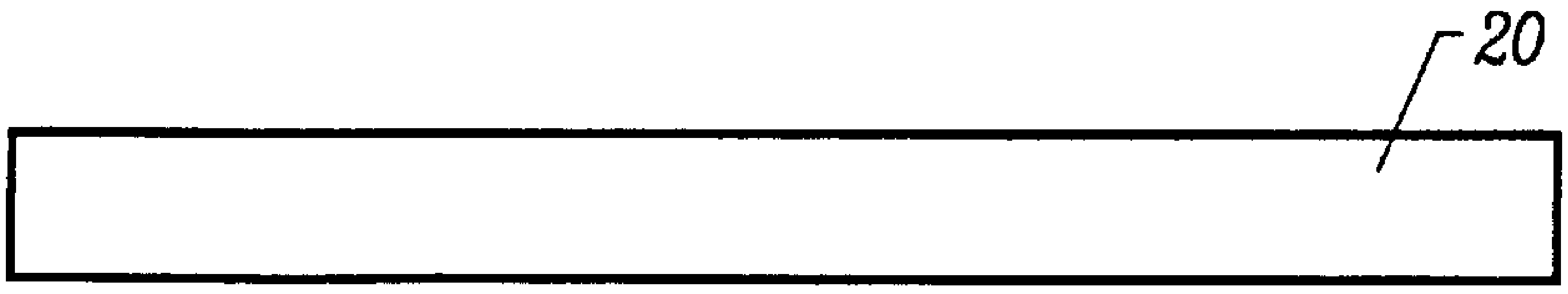


FIG. 1A

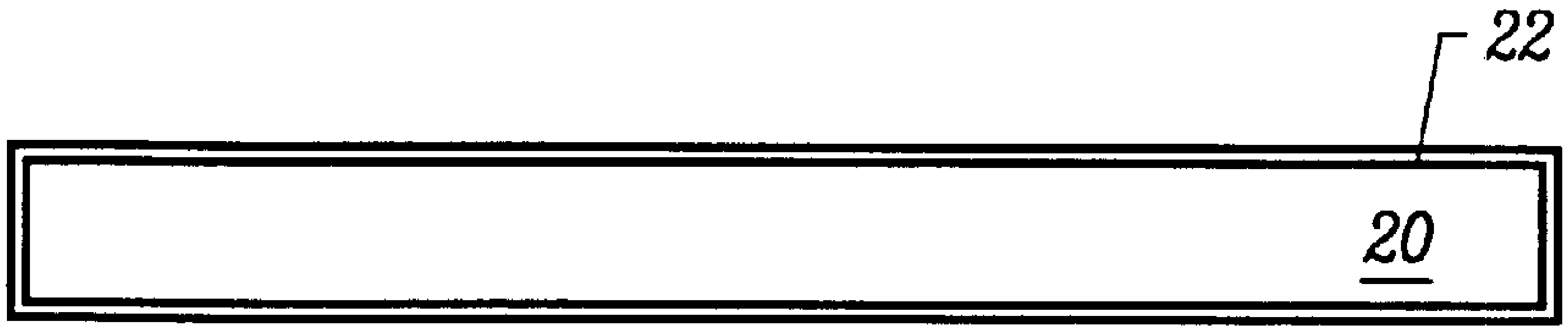


FIG. 1B

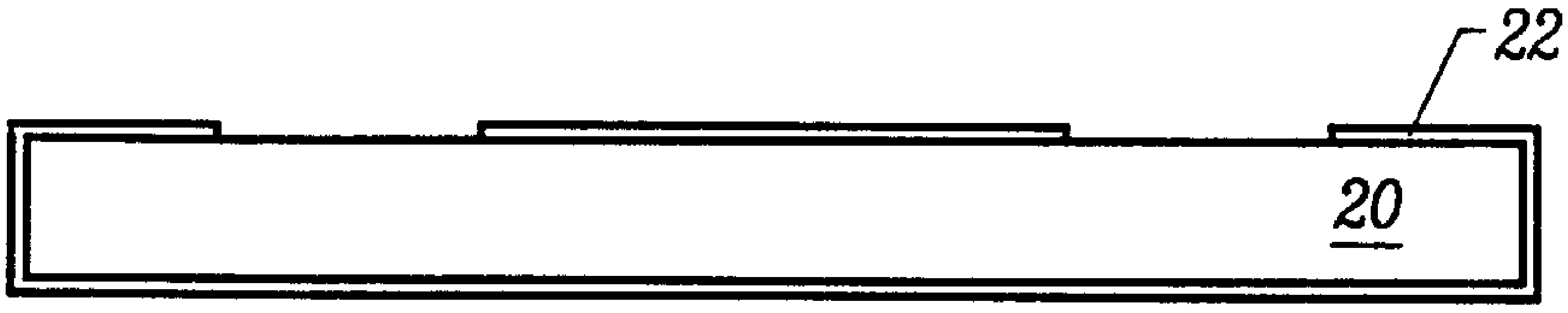


FIG. 1C

FIG. 1D

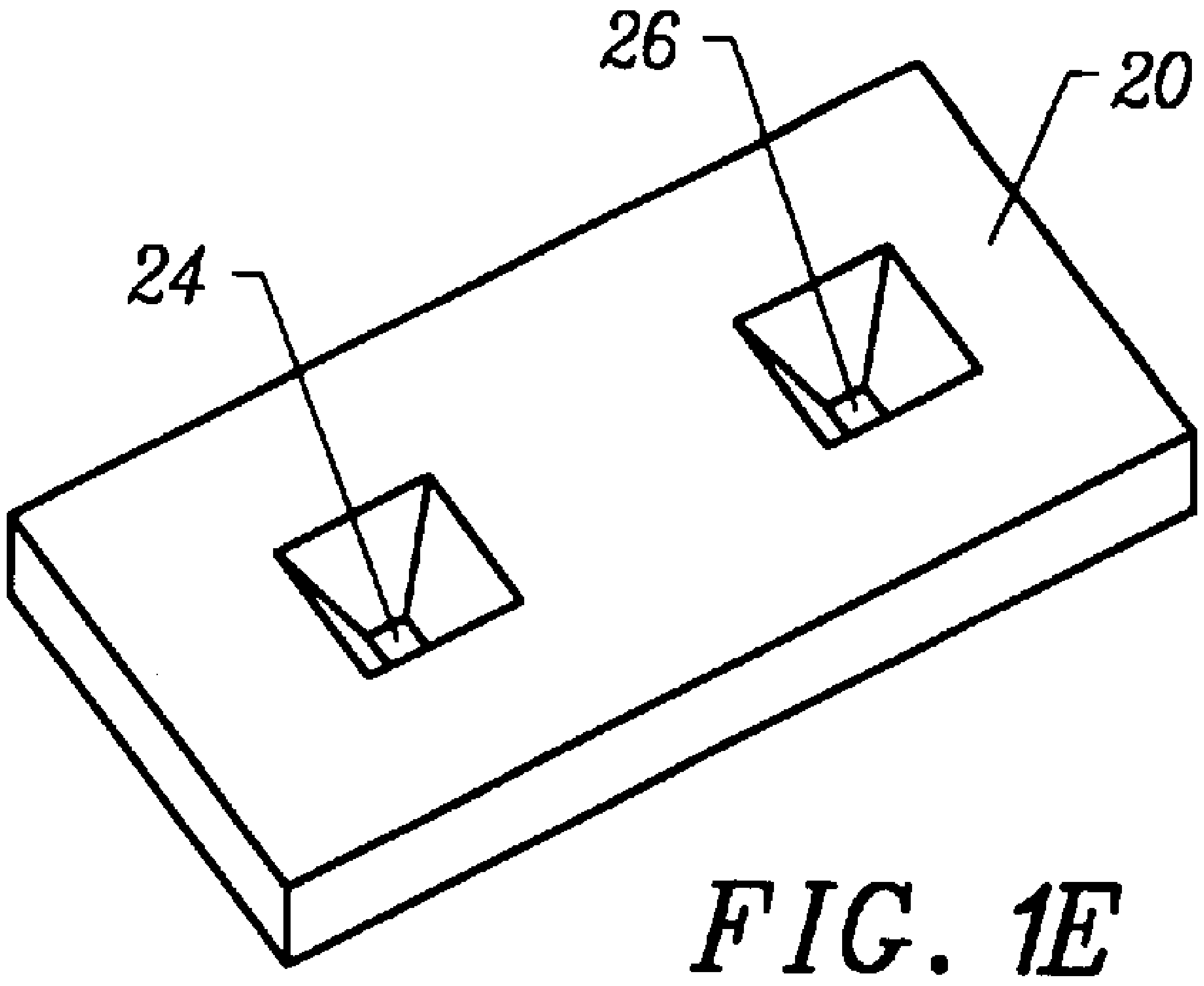


FIG. 1E

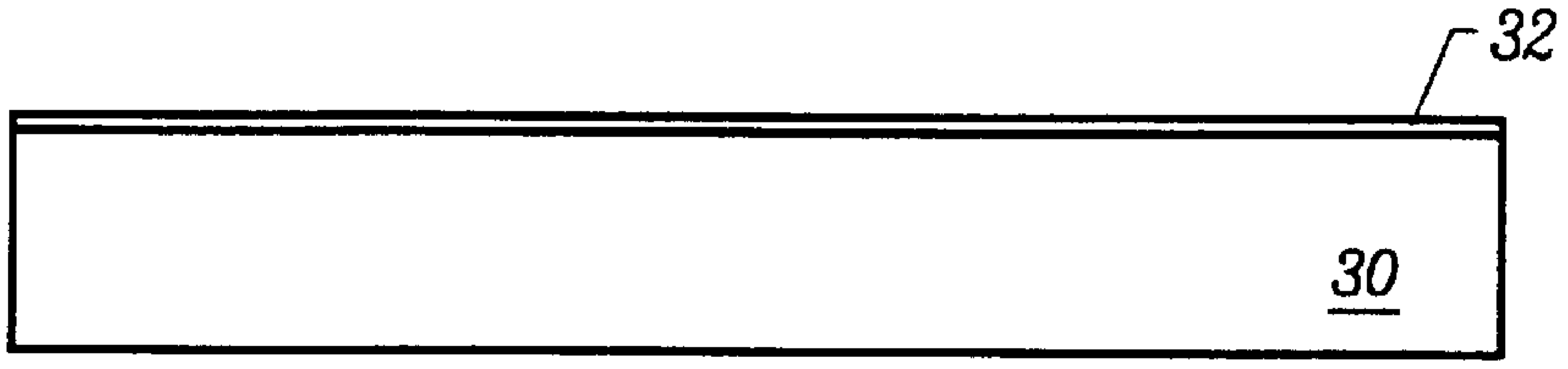


FIG. 2A

FIG. 2B

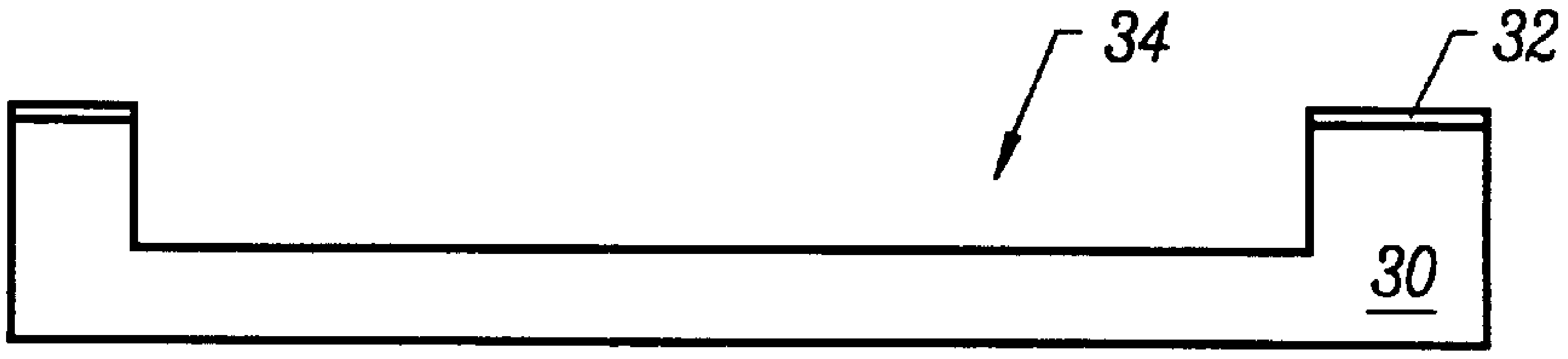


FIG. 2C

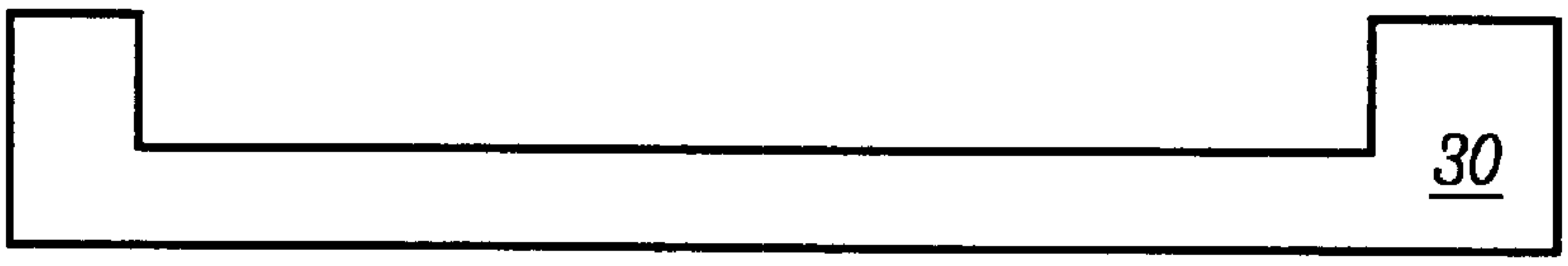


FIG. 2D

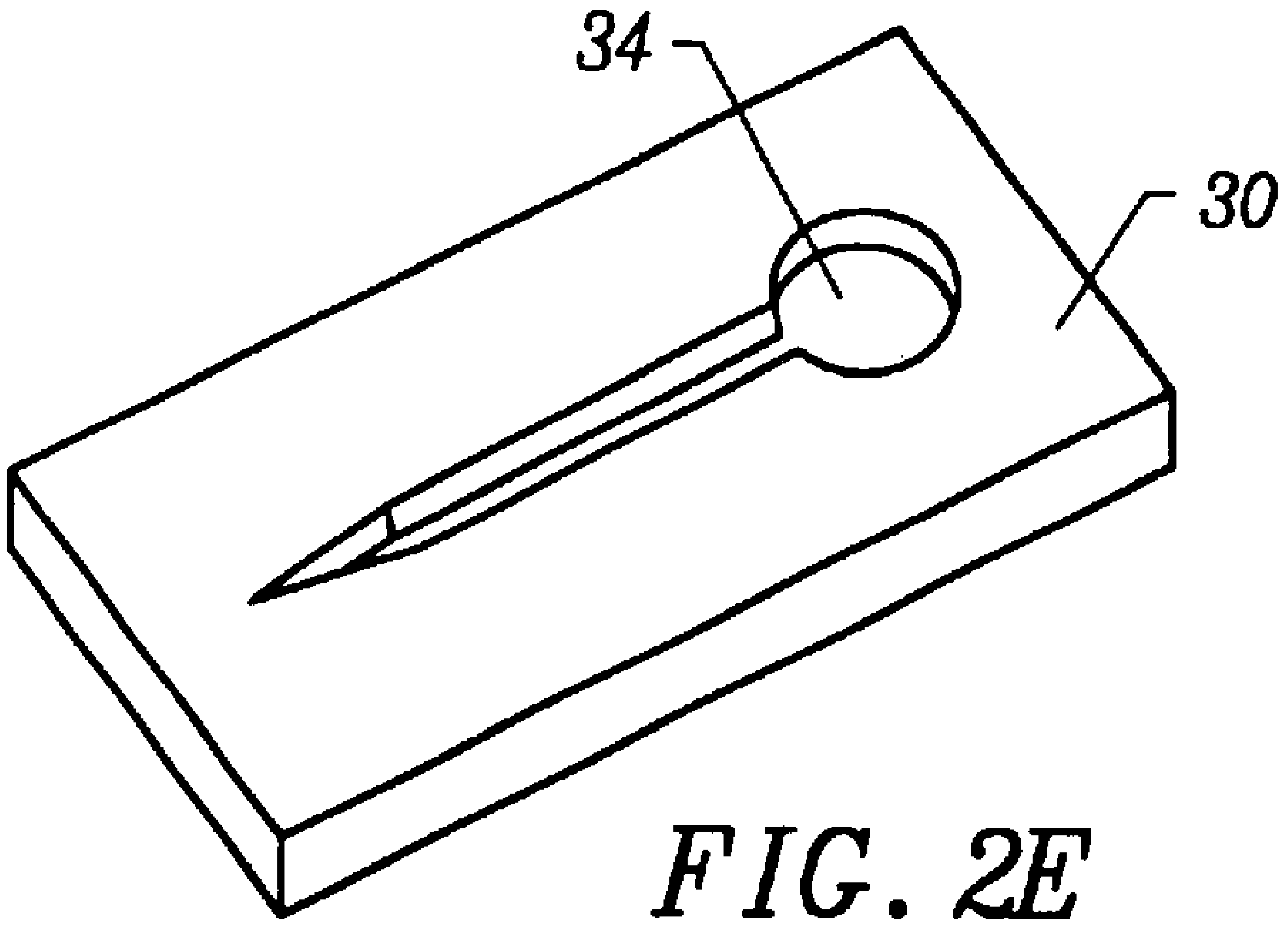


FIG. 2E

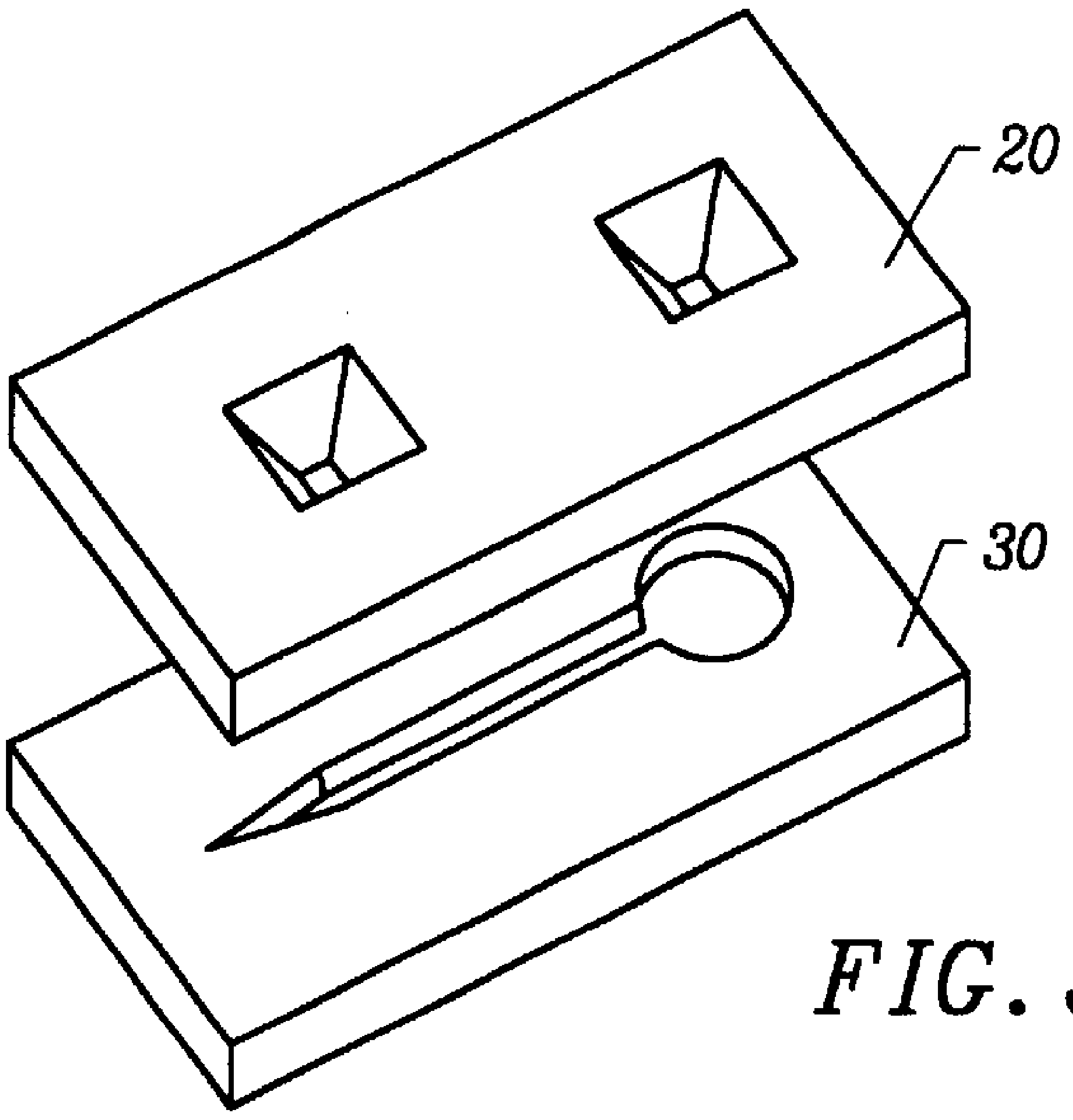


FIG. 3A

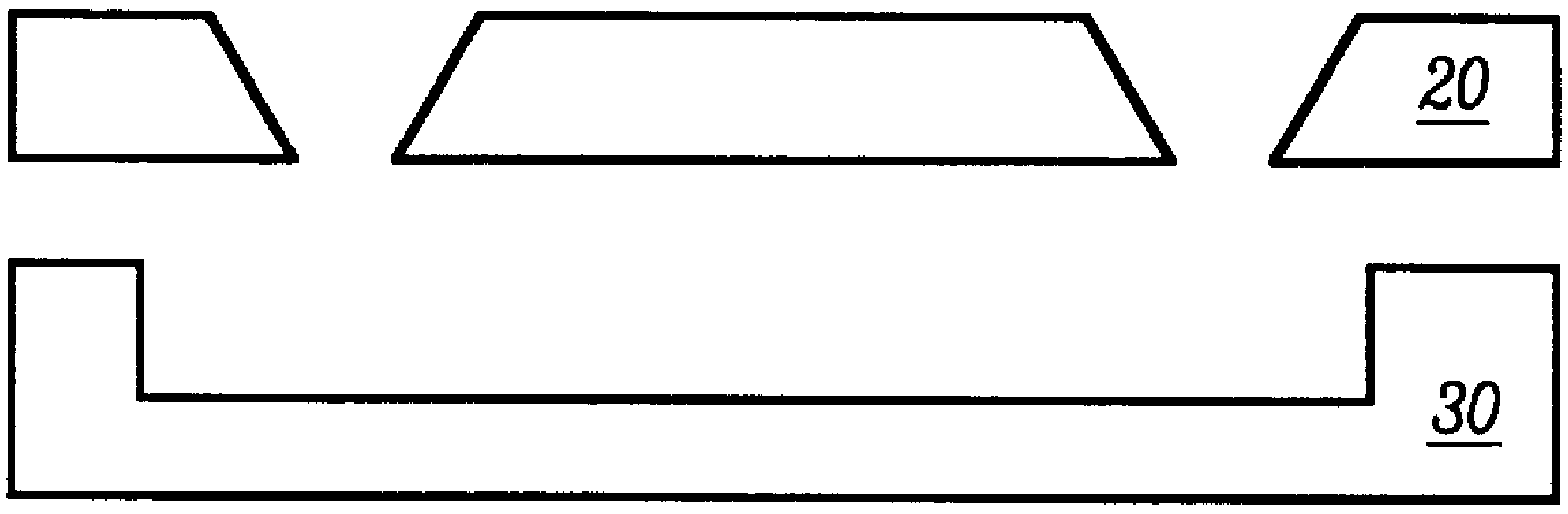


FIG. 3B

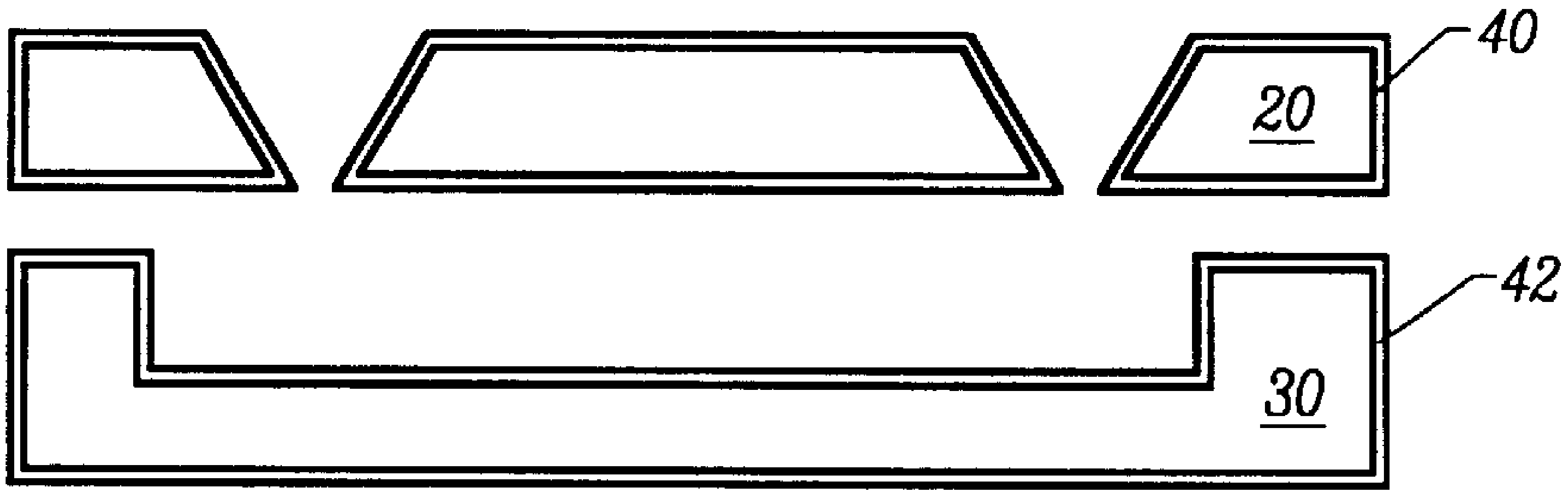


FIG. 3C

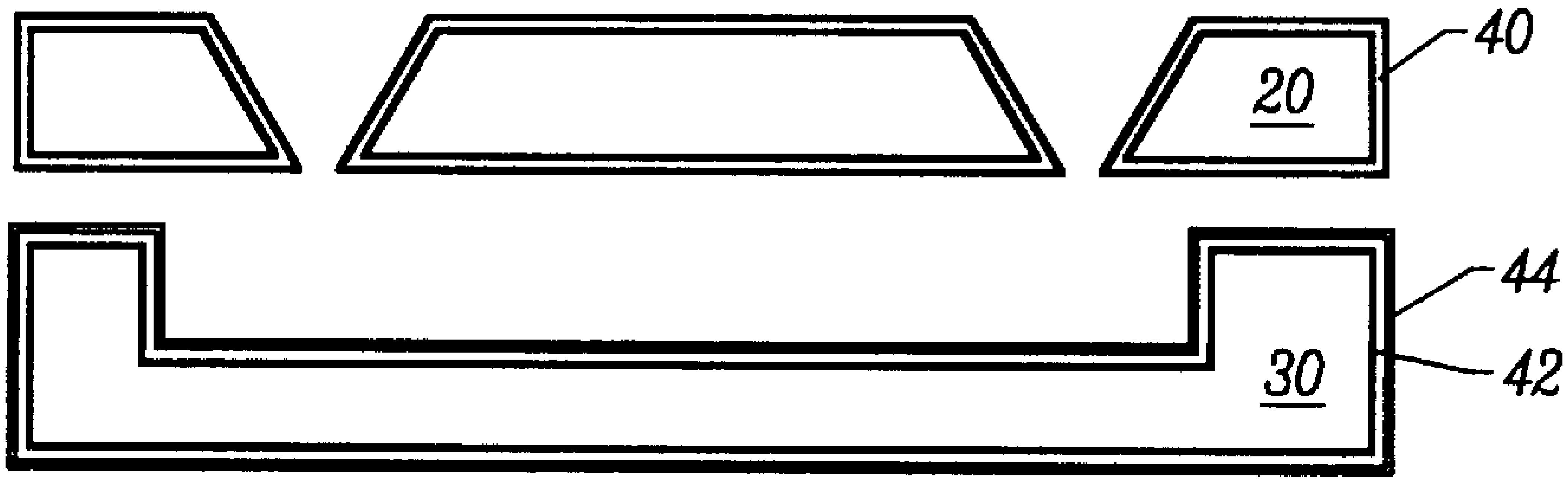


FIG. 3D

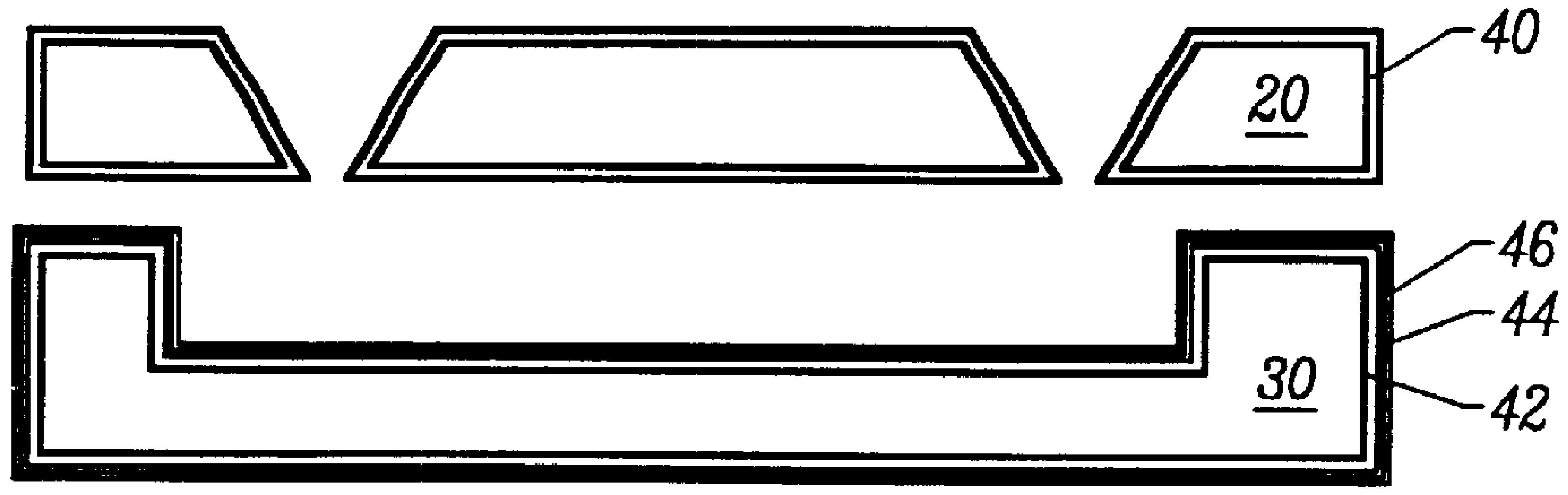


FIG. 3E

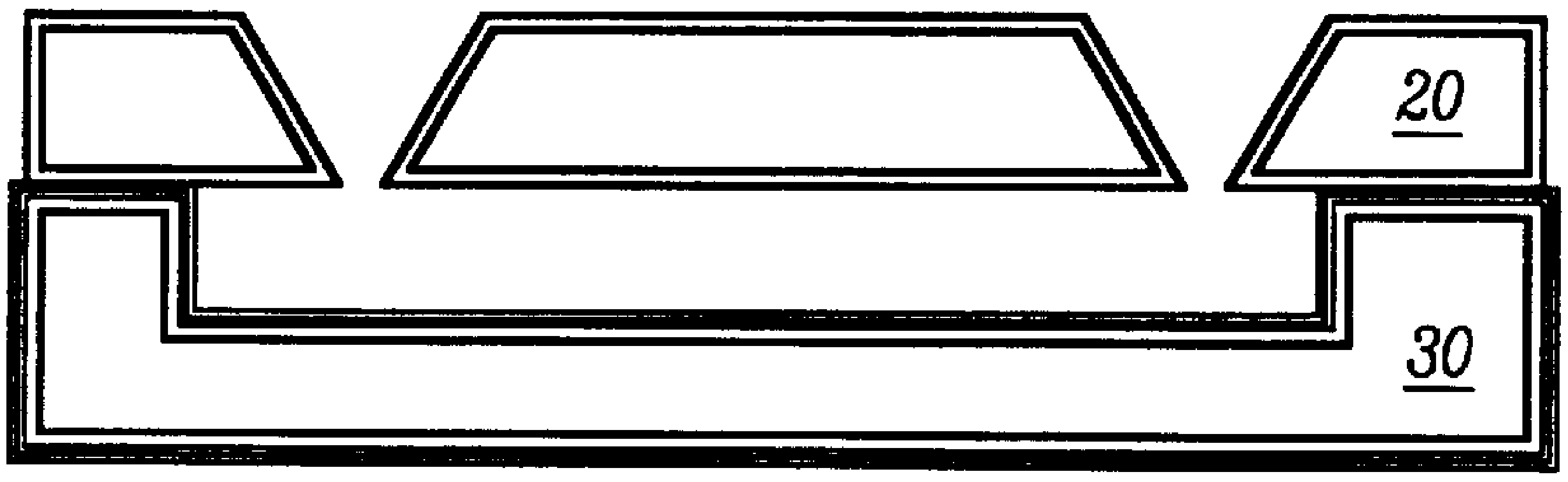


FIG. 3F

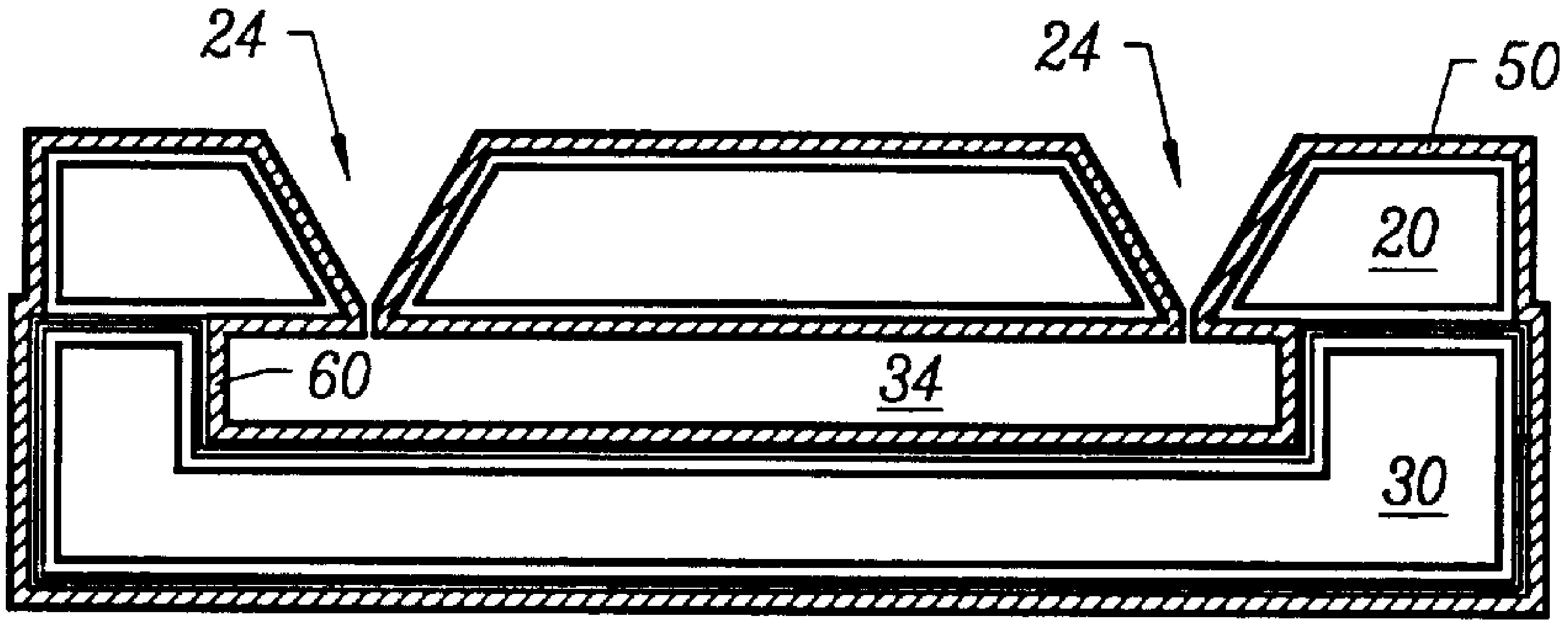


FIG. 3G

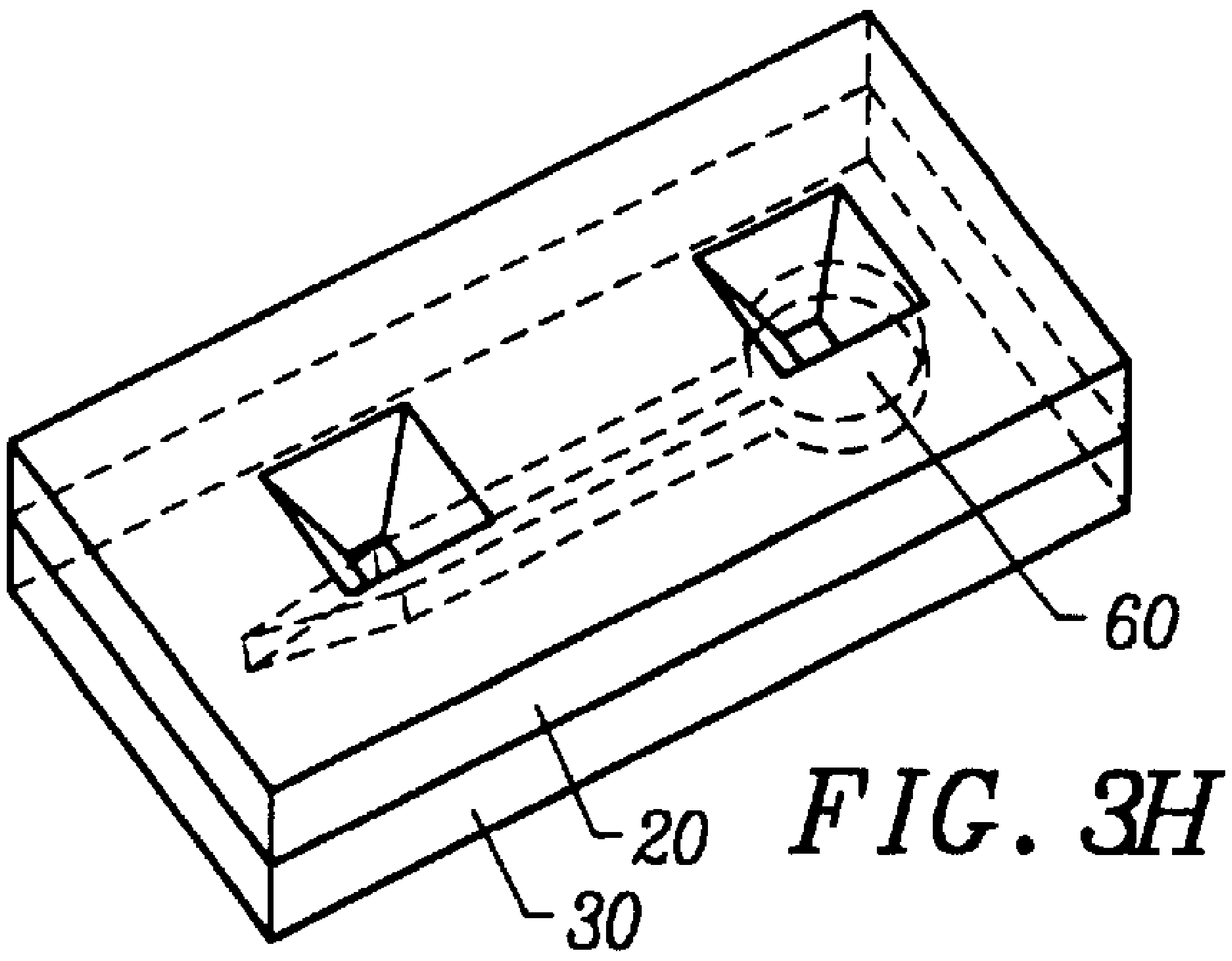


FIG. 3H

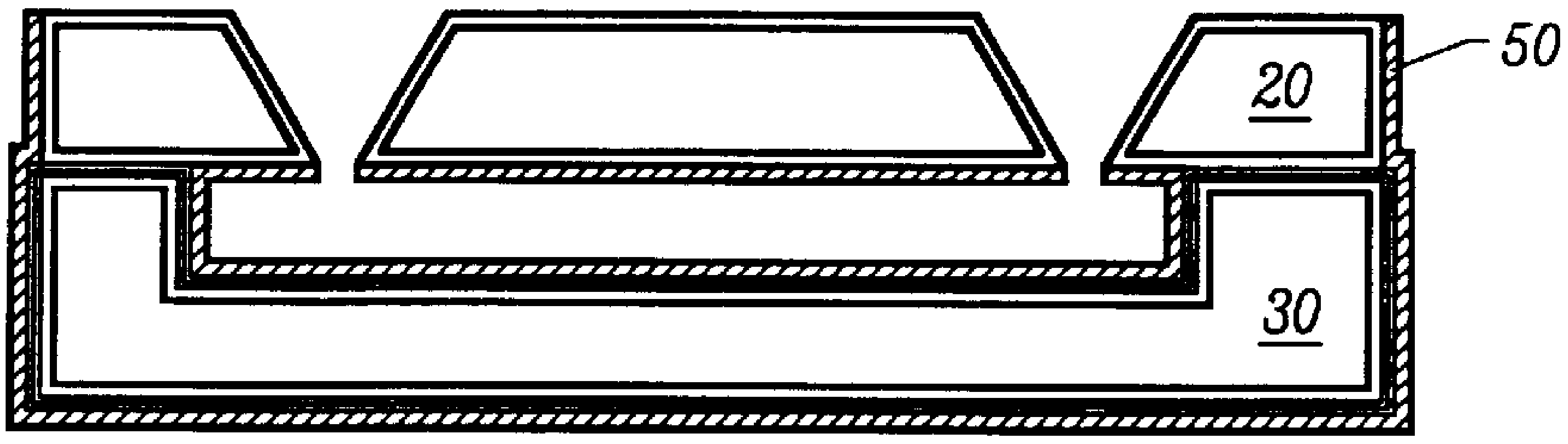


FIG. 3I

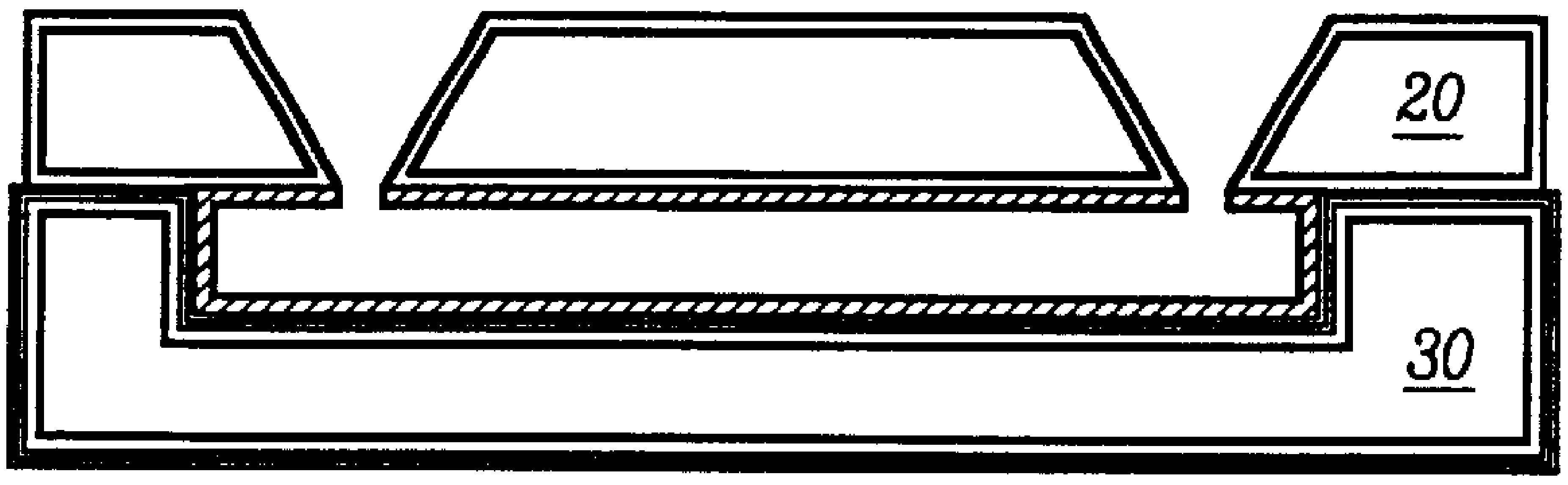


FIG. 3J

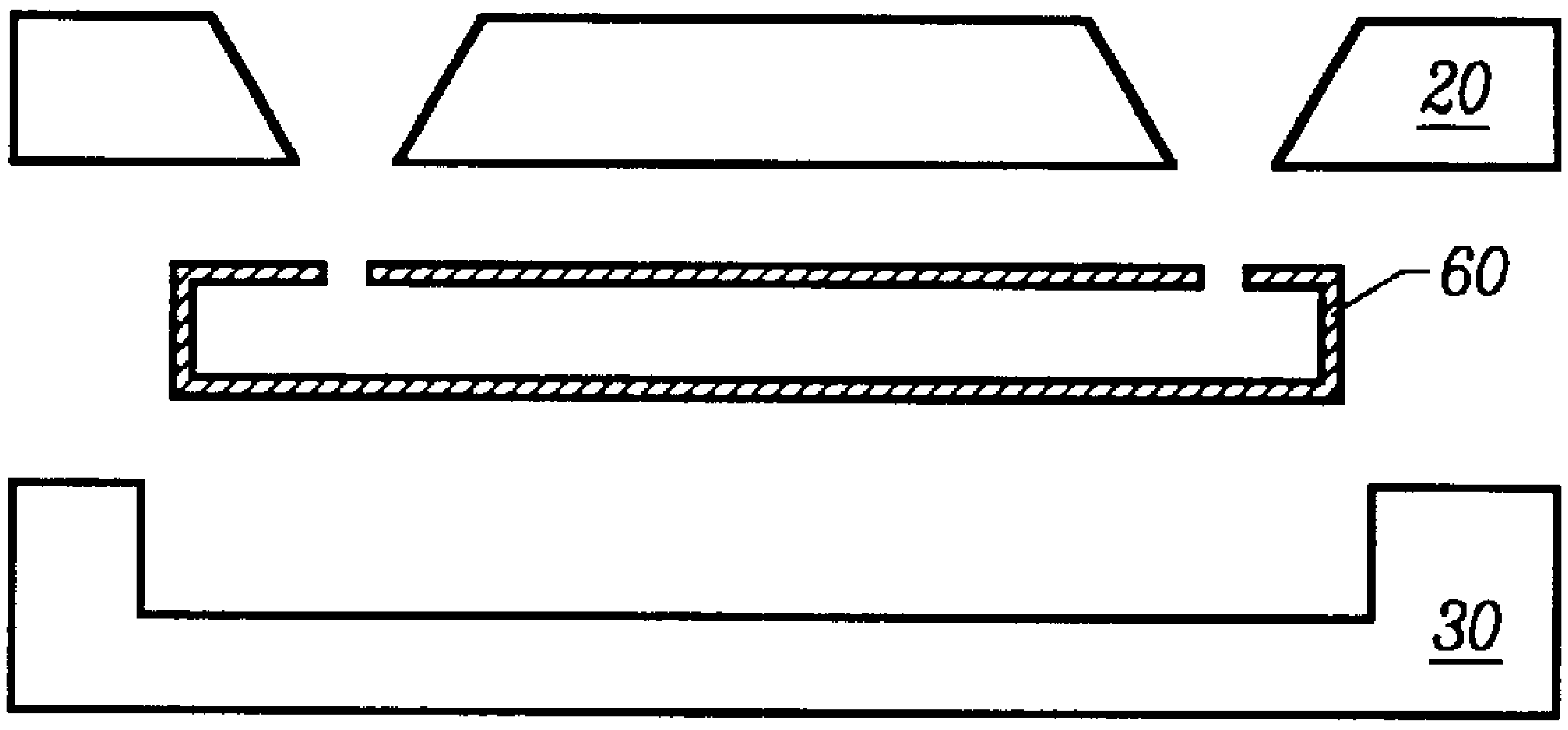


FIG. 3K

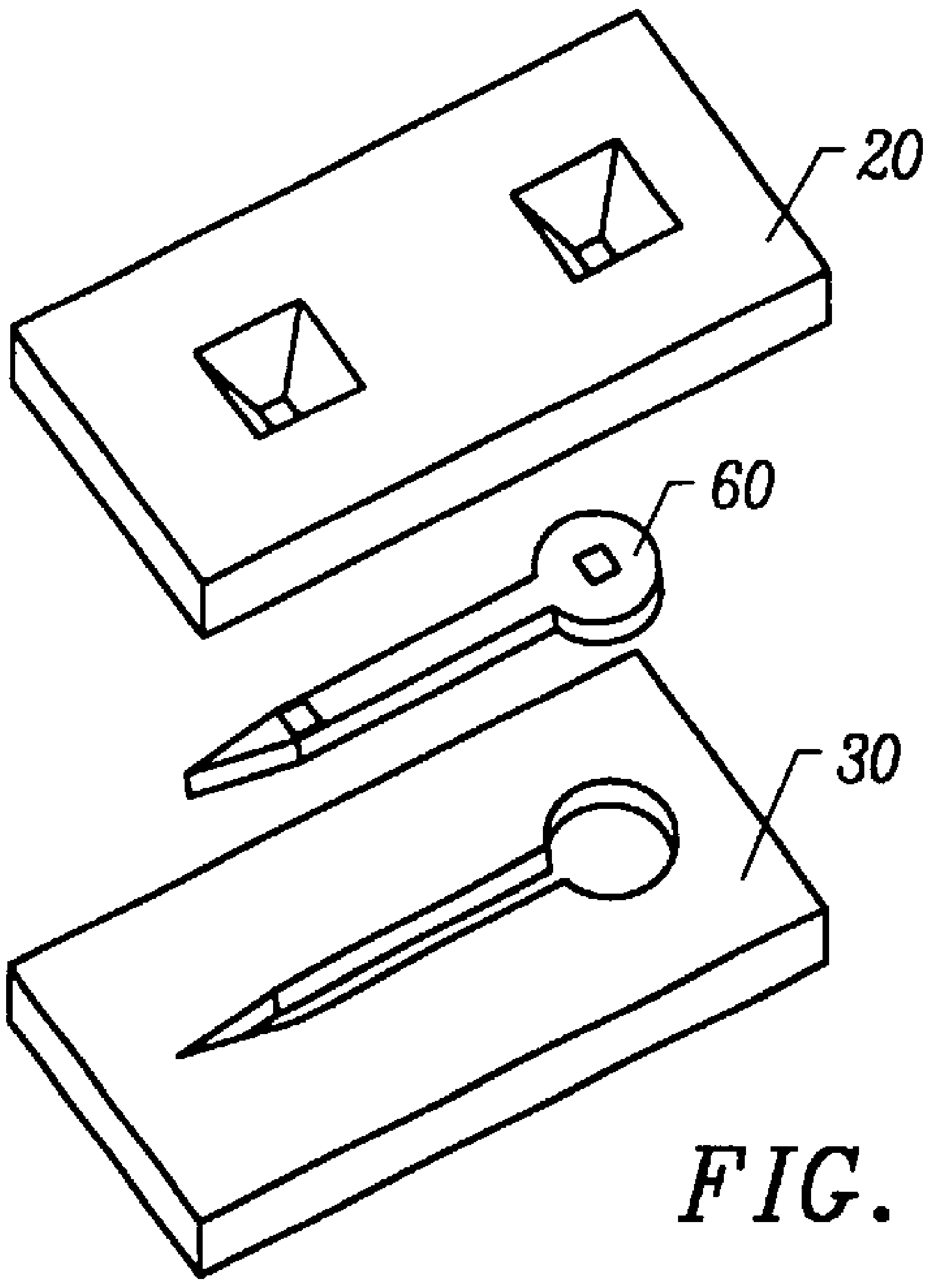


FIG. 3L

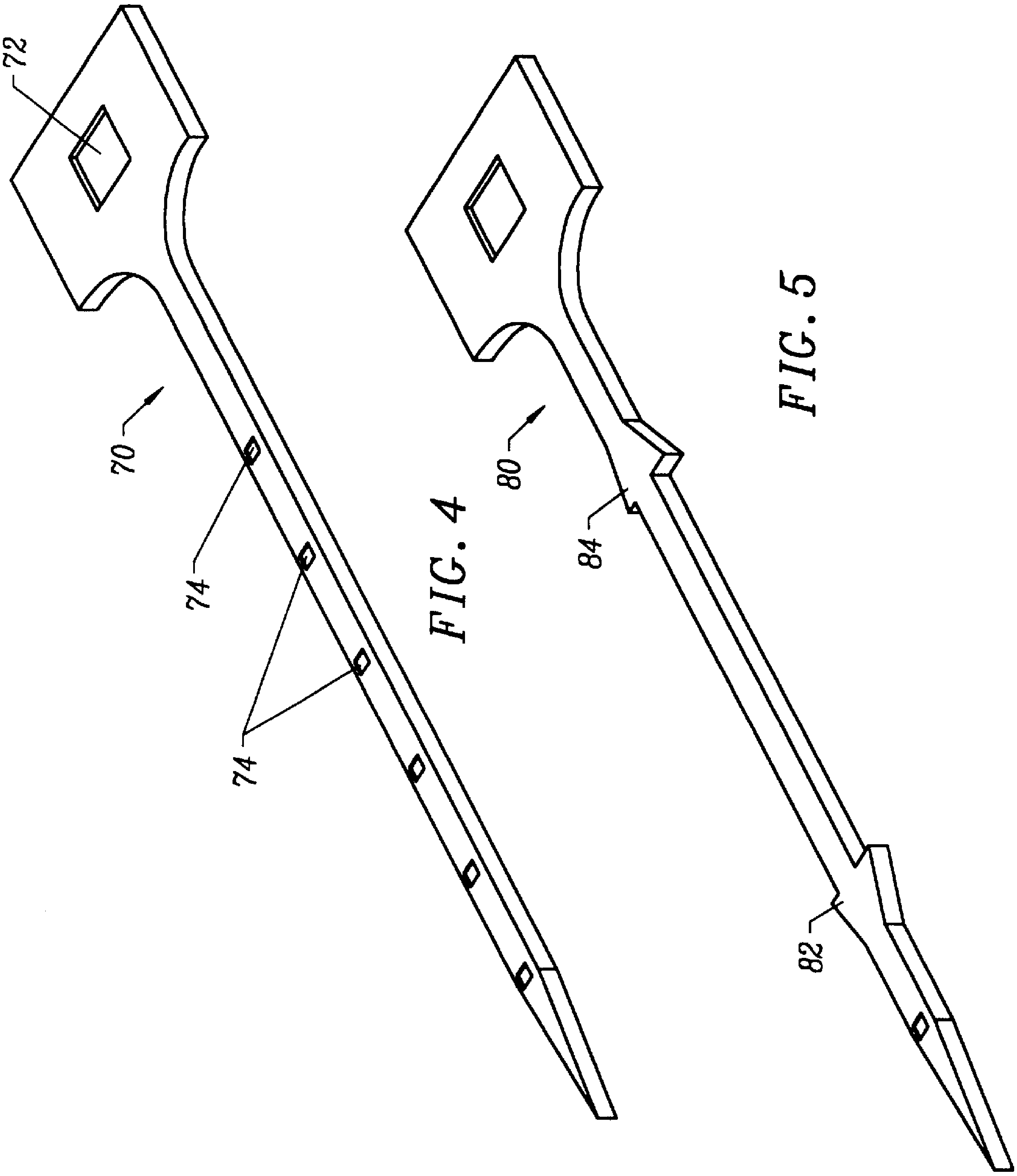


FIG. 4

FIG. 5

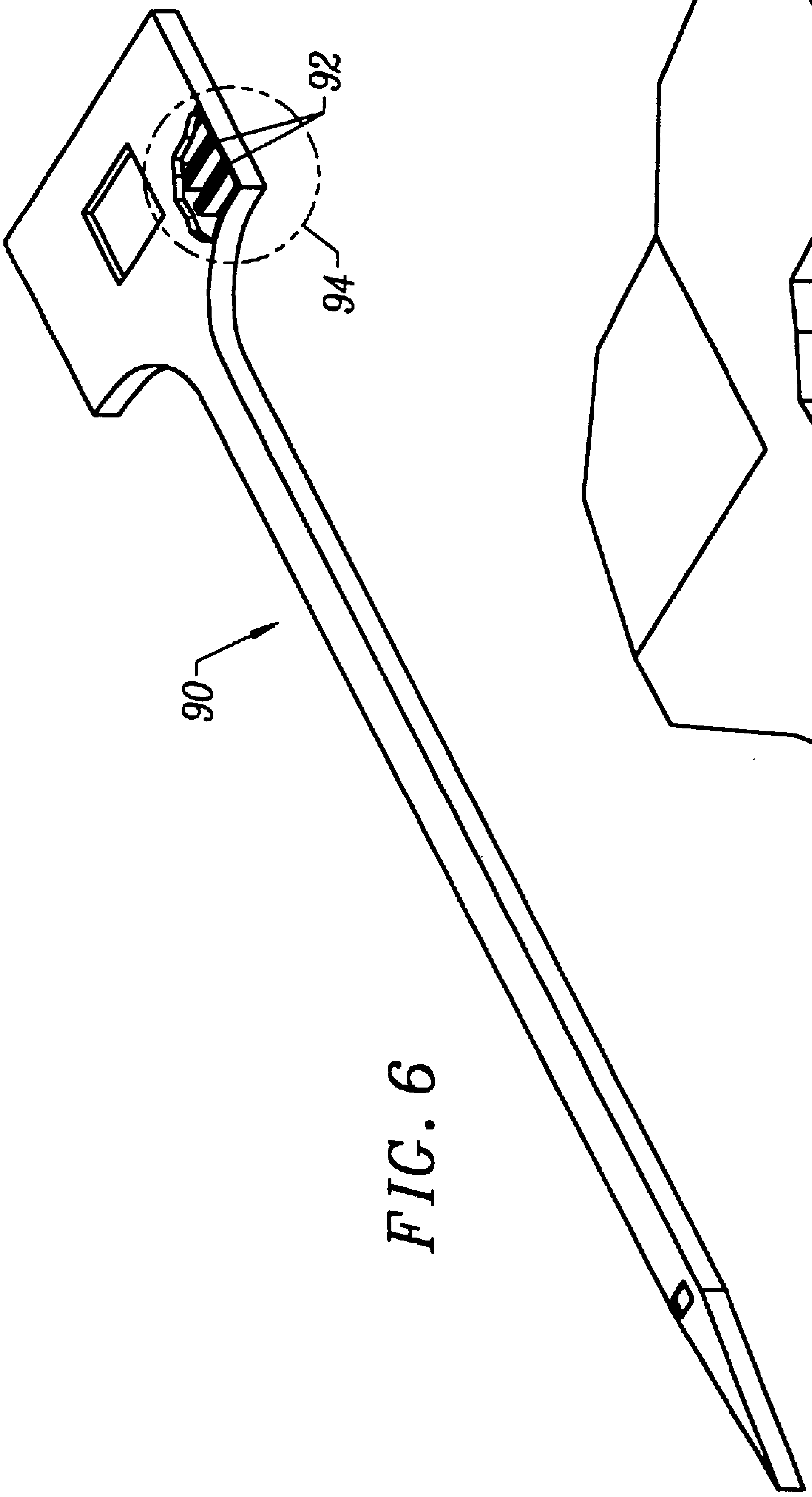


FIG. 6

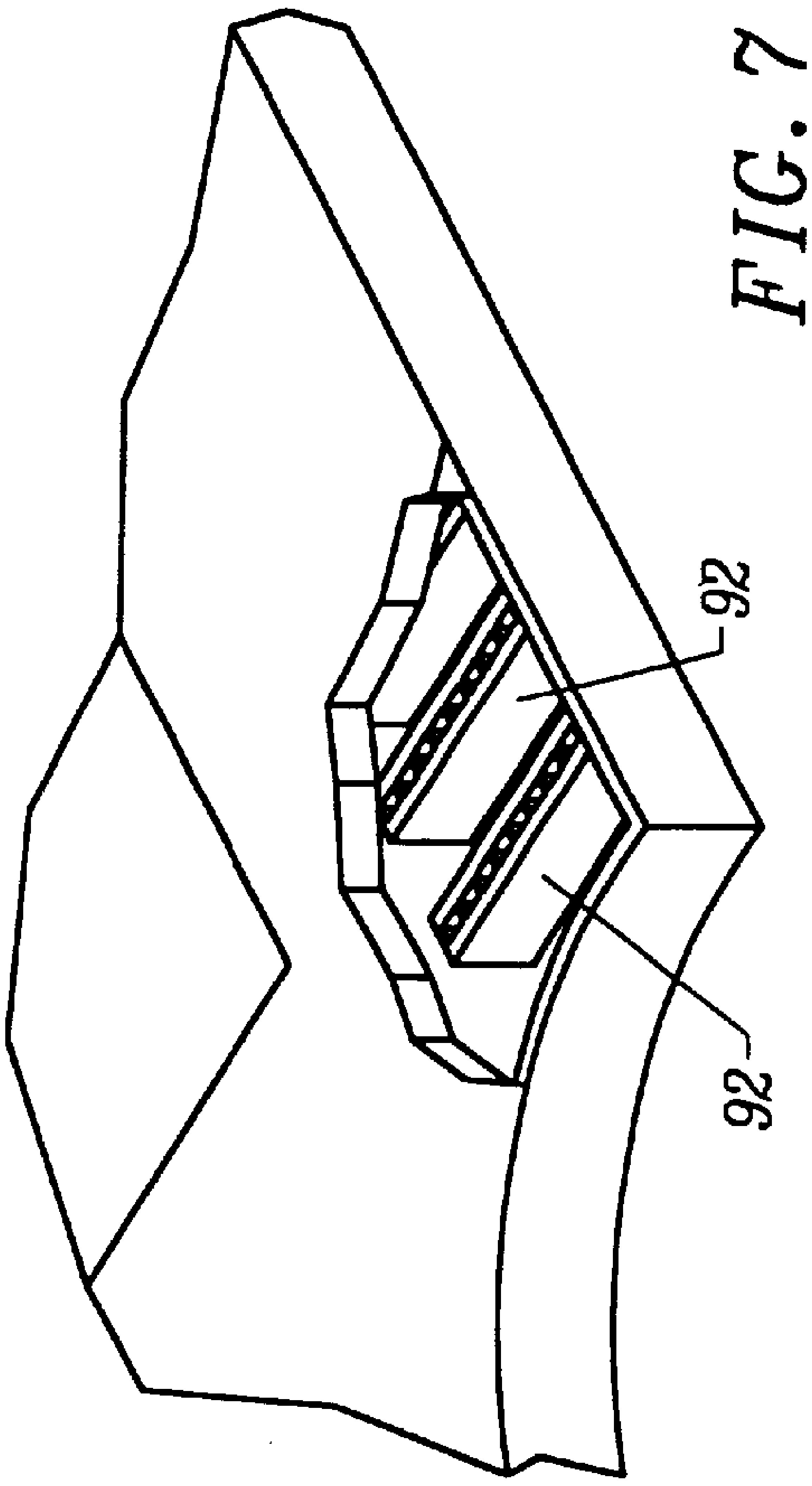


FIG. 7

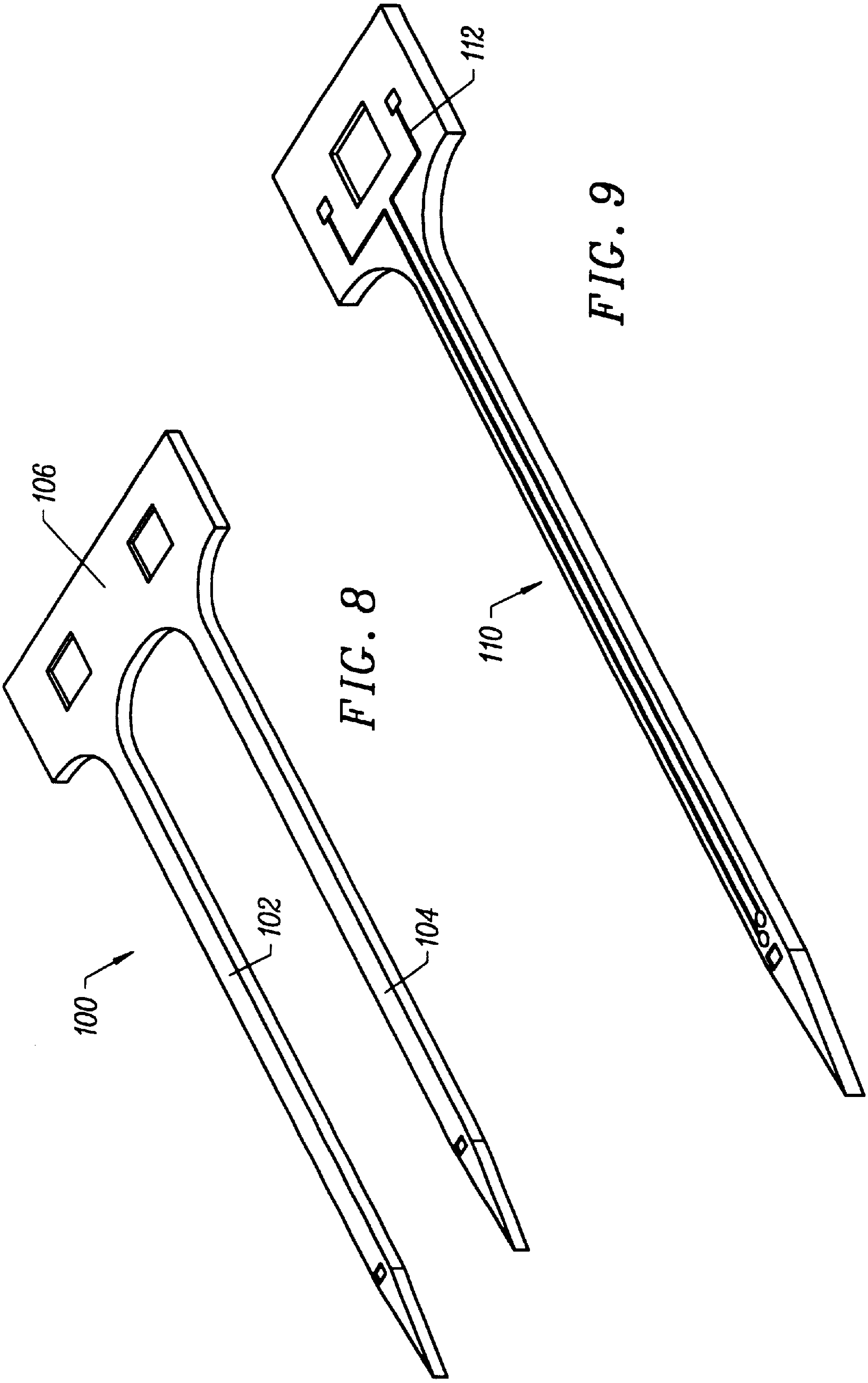


FIG. 9

FIG. 8

APPARATUS FOR FABRICATING NEEDLES VIA CONFORMAL DEPOSITION IN TWO-PIECE MOLDS

This is a division of application Ser. No. 09/044,398, filed Mar. 18, 1998 now U.S. Pat. No. 6,106,751.

BRIEF DESCRIPTION OF THE INVENTION

This invention relates generally to hypodermic needles. More particularly, this invention relates to a technique for fabricating needles via conformal deposition in two-piece molds.

BACKGROUND OF THE INVENTION

Traditional machining techniques, such as, tube drawing, grinding, and polishing are used to fabricate needles. While satisfactory for simple needle designs, these techniques cannot be used to fabricate more sophisticated features and geometries that provide extended functionality. For example, a needle with two fluid channels to allow the simultaneous injection of two fluids to the same area is very difficult to fabricate with traditional needle machining techniques. Electronic circuitry, such as, electrodes and amplification circuitry may be used for charge delivery, electric field sensing, or electrophoretic pumping. Biological sensors to provide, for example, biological assay capability, would be extremely useful. Insertion and extraction limiting barbs are also potentially very useful. Additionally, a pump built into the needle and multiple inlet and outlet ports are highly desirable features. A dual prong needle would allow delivery through one prong and sensing in the other. These features are very difficult to implement with traditional machining.

Recently, silicon microfabrication techniques have been used to construct hypodermic needles. For example, microfabrication processes to produce needles are described in the work by Chen and Wise (J. Chen et al., "A Multichannel Neural Probe for the Selective Chemical Delivery at the Cellular Level", Solid State Sensor and Actuator Workshop, Hilton Head, S.C., 1994) and also by Linn (Liwei L. Linn, et al., "Silicon Processed Microneedles", *Technical Digest,* 7th International Conference on Solid-State Sensors and Actuators, Transducers '93, Yokohama, Japan, Jun. 7–10, 1993). There are two drawbacks with this early work. First, the disclosed processes are destructive to the wafer from which the needles are produced. Second, the processes do not rely upon a mold. Thus, new wafers must be used each time the process is repeated. This results in considerable added expense.

Single mold processes to make needles are known in the art. For example, the HexSil process invented by Chris Keller (Christopher G. Keller et al., "Nickel-Filled HexSil Thermally Actuated Tweezers", *Technical Digest,* Transducers 95, Stockholm, Sweden, Jun. 25–29, 1995, pp. 376–379) is a single wafer micromolding process. Unfortunately, the Hexsil process can only form relatively short needles (generally less than a millimeter).

In view of the foregoing, it would be highly desirable to provide an improved technique for fabricating hypodermic needles. Ideally, the technique would allow the fabrication of needles with extended functionality, such as multiple fluid channels, multiple ports, and integrated circuitry. In addition, the technique would preferably avoid prior art problems of limited needle length. Ideally, the technique would provide a re-usable mold process to reduce fabrication expense.

SUMMARY OF THE INVENTION

A method of fabricating a needle via conformal deposition in a two-piece mold includes the step of attaching a top mold member to a bottom mold member such that the top mold member and the bottom mold member define an enclosed, elongated needle trench with a deposition aperture. A conformal substance, such as polysilicon, is then passed through the deposition aperture such that the conformal substance is deposited within the enclosed, elongated needle trench to form a needle. The method is used to form needles with prongs, multiple channels, multiple ports, barbs, strength enhancement features, and circuitry.

The invention constitutes an improved technique for fabricating hypodermic needles. The re-usable mold process reduces fabrication expense. In addition, the mold process of the invention provides for longer needles than available in prior art mold processes.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference should be made to the following detailed description taken in conjunction with the accompanying drawings, in which:

FIGS. **1***a*–**1***e* illustrate the processing of a top mold member in accordance with an embodiment of the invention.

FIGS. **2***a*–**2***e* illustrate the processing of a bottom mold member in accordance with an embodiment of the invention.

FIGS. **3***a*–**3***l* illustrate the processing of a combined top mold member and bottom mold member in accordance with an embodiment of the invention.

FIG. **4** is a perspective view of a needle with multiple fluid ports in accordance with an embodiment of the invention.

FIG. **5** is a perspective view of a needle with insertion and extraction barbs in accordance with an embodiment of the invention.

FIG. **6** is a perspective view of a needle with strength enhancement features in accordance with an embodiment of the invention.

FIG. **7** is an enlarged view of the strength enhancement features of the needle of FIG. **6**.

FIG. **8** is a perspective view of a dual prong needle in accordance with an embodiment of the invention.

FIG. **9** is a perspective view of a needle with circuitry in accordance with an embodiment of the invention.

Like reference numerals refer to corresponding parts throughout the drawings.

DETAILED DESCRIPTION OF THE INVENTION

In brief, the invention includes a method of fabricating a needle via conformal deposition in a two-piece mold. The method includes the step of attaching a top mold member to a bottom mold member such that the top mold member and the bottom mold member define an enclosed, elongated needle trench with a deposition aperture. A conformal substance, such as polysilicon, is then passed through the deposition aperture such that the conformal substance is deposited within the enclosed, elongated needle trench to form a needle. The method is used to form needles with prongs, multiple channels, multiple ports, barbs, strength enhancement features, and circuitry, as demonstrated below.

The following processing steps have been used to construct a variety of devices, in accordance with the invention. Those skilled in the art will appreciate that a variety of modifications to the specified steps are feasible, yet still within the scope of the invention.

Table I—Preferred Fabrication Steps

A. STANDARD WAFER CLEAN

VLSI lab sink

Piranha clean (H_2SO_4:H_2O_2, 5:1) 10 minutes

Two, one minute rinses in de-ionized (DI) water

Rinse until resistivity of water is >11 MΩ-cm

Spin dry

Piranha clean (H_2SO_4:H_2O_2, 5:1) 10 minutes

Rinse in DI water for one minute

Dip in 25:1 HF until hydrophobic

Two, one minute rinses in de-ionized (DI) water

Rinse until resistivity of water is >14 MΩ-cm

Spin dry

B. CLEAN WAFERS WITH MINIMAL OXIDE STRIP

VLSI lab sink

Piranha clean (H_2SO_4:H_2O_2, 5:1) 10 minutes

Rinse in DI water for one minute

Dip in 25:1 HF briefly until native silicon oxide removed

Two, one minute rinses in DI water

Rinse until resistivity of DI water is >14 MΩ-cm

Spin dry

C. PARTIAL CLEAN WAFERS

VLSI lab sink

Piranha clean (H_2SO_4:H_2O_2, 5:1) 10 minutes

Two, one minute rinses in de-ionized (DI) water

Rinse until resistivity of water is >11 MΩ-cm

Spin dry

D. DEPOSIT LOW-STRESS SILICON NITRIDE

Horizontal low pressure chemical vapor deposition reactor

Target thickness as specified

Conditions=835° C., 140 mTorr, 100 sccm DCS, and 25 sccm NH_3

E. DEPOSIT PHOSPHOSILICATE GLASS (PSG)

Horizontal low pressure chemical vapor deposition reactor

Target thickness as specified

Conditions=450° C., 300 mTorr, 60 sccm SiH_4, 90 sccm O_2, and 10.3 sccm PH_3

Step G.—REFLOW PHOSPHOSILICATE GLASS

F. DEPOSIT LOW TEMPERATURE OXIDE (LTO)

Horizontal low pressure chemical vapor deposition reactor

Target thickness as specified

Conditions=450° C., 300 mTorr, 60 sccm SiH_4, 90 sccm O_2, and 10.3 sccm PH_3

Step G.—REFLOW PHOSPHOSILICATE GLASS

G. REFLOW PHOSPHOSILICATE GLASS

Horizontal atmospheric pressure reactor

Conditions=1000° C., N_2, 1 hour

H. PHOTOLITHOGRAPHY

1. HMDS prime
2. Photoresist coat
   Coat 1 μm of Shipley S3813 (thickness may need to be varied depending on topography and thickness of material to be etched) multi-wavelength positive resist
3. Expose resist
   G-Line wafer stepper
   Standard exposure time
4. Resist develop
   Standard develop using Shipley MF 319
5. Hard bake for 30 minutes

I. COAT BACKSIDE WITH PHOTORESIST

1. HMDS prime
2. Photoresist coat
   Coat 1 μm of Shipley S3813 (thickness may need to be varied depending on topography and thickness of material to be etched) multi-wavelength positive resist
3. Resist develop
   Standard develop using Shipley MF 319
4. Hard bake for 30 minutes

J. OXIDE WET ETCHING

VLSI lab sink

Etch in 5:1 BHF until desired amount of oxide has been removed

Two, one minute rinses in DI water

Rinse until resistivity of water is >11 MΩ-cm

Spin dry

K. PHOTORESIST STRIP

Lab sink

PRS-2000, heated to 90° C., 10 minutes

Rinse in three baths of DI water, 2 minutes each

Step C.—PARTIAL CLEAN WAFERS

L. SILICON NITRIDE ETCH

SF_6+He plasma etch

Etch until desired amount of nitride has been removed

M. DEPOSIT UNDOPED POLYSILICON

Horizontal low pressure chemical vapor deposition reactor

Target thickness as specified

Conditions=580° C., 300 mTorr, and 100 sccm SiH_4

N. ANISOTROPIC POLYSILICON ETCH

Chlorine plasma etch

Etch until desired amount of polysilicon has been removed

O. NITROGEN ANNEAL

Horizontal atmospheric pressure reactor

Conditions=1000° C., N_2, 1 hour

P. ANISOTROPHIC SILICON WET ETCH

Lab sink, heated bath

750 g KOH: 1500 ml H_2O

Temperature: 80° C.

Q. OXIDE REMOVAL WET ETCHING

Lab sink

Etch in diluted HF or buffered HF until desired oxide removed

Rinse in deionized water for approximately one hour

R. NEAR VERTICAL WALLED TRENCH ETCH

Inductively coupled plasma etcher

Advanced silicon etch process

High plasma density low pressure processing system

Fluorine plasma

Etch to desired depth

S. SACRIFICIAL PSG AND SILICON NITRIDE REMOVAL

Lab sink

Concentrated HF dip with surfactant if needed, continue until desired sacrificial material has been removed

Rinse for 2 minutes in two tanks of DI water

Rinse for 120 minutes in third tank of DI water

T. SPUTTER GOLD
  Low pressure chamber
  Gold target
U. GOLD ETCH
  Lab sink
  Aqua regent etchant or other commercially available gold etchant
V. WET OXIDATION
  Horizontal atmospheric pressure reactor
  Conditions=Temperature as specified, water vapor environment
W. BORON DIFFUSION
  Horizontal atmospheric pressure reactor
  Solid source boron diffusion
  Conditions=Temperature as specified
X. DEPOSIT IN SITU DOPED POLYSILICON
  Horizontal low pressure chemical vapor deposition reactor
  Target thickness as specified
  Conditions=610° C. and 300 mTorr

FIGS. **1***a*–**1***e* illustrate the construction of a top mold member in accordance with an embodiment of the present invention. FIG. **1***a* illustrates a starting wafer **20**, which may be 500 to 500 micron thick, <100>oriented, lightly doped silicon. The wafer is cleaned (Step A) and 4000 Å of silicon nitride is deposited (Step D). The resultant silicon nitride layer **22** is illustrated in FIG. **1***b*. Photolithography (Step H) is then performed. The silicon nitride is then etched (Step L). Preferably, 5000 Å is etched for a 25% over-etch. The photoresist is then stripped (Step K), to produce the device of FIG. **1***c*. An anisotropic silicon wet etch (Step P) is then performed through the wafer. Finally, the silicon nitride is removed (Step S). FIG. **1***d* provides a side view of the resultant device **20**, while FIG. **1***e* provides a perspective view of the device **20**. The top mold member **20** includes deposition apertures **24** and **26**.

While FIGS. **1***a*–**1***e* illustrate a single mold member **20**, those skilled in the art will appreciate that typically over a thousand molds are prepared at once. Furthermore, the foregoing steps are only performed once to create the top mold member **20**. Thereafter, the top mold member **20** can be reused to construct several batches of needles.

FIGS. **2***a*–**2***e* illustrate the construction of a bottom mold member in accordance with an embodiment of the invention. FIG. **2***a* illustrates a starting wafer **30**, which may be 500 to 500 micron thick, <100>oriented, lightly doped silicon. The wafer is cleaned (Step A). Thereafter, photoresist is spun onto the wafer **30**, resulting in photoresist layer **32**. Photolithography (Step H) is then performed to define a needle shape, which results in the device of FIG. **2***b*. A deep trench etch (Step R) is then performed to a depth of approximately 100 microns. The resultant needle trench **34** is illustrated in FIG. **2***c*. The photoresist is then stripped (Step K), to produce the device of FIG. **2***d*. FIG. **2***d* provides a side view of the resultant device **30**, while FIG. **2***e* provides a perspective view of the device **30**. The bottom mold member **30** includes a needle trench **34** defining the shape of a needle. In particular, the mold member **30** defines an elongated needle trench **34**. When the top mold member **20** and the bottom mold member **30** are attached, an enclosed, elongated needle trench results. Deposition of a conformal substance into the trench produces a needle, as described below.

While FIGS. **2***a*–**2***e* illustrate a single mold member, those skilled in the art will appreciate that typically over a thousand molds are prepared at once. Furthermore, the foregoing steps are only performed once to create the bottom mold member **30**. Thereafter, the bottom mold member **30** can be reused to construct several batches of needles.

At this juncture, a top mold member **20** and a bottom mold member **30** are available. A perspective view of these elements is shown in FIG. **3***a,* and a side view of the same elements is shown in FIG. **3***b*. The following discussion is directed toward needle fabrication steps using these mold members. The top mold member **20** and the bottom mold member **30** are subjected to a standard wafer clean (Step A). Approximately 2 microns of phosphosilicate glass is then deposited on the top mold member **20** and the bottom mold member **30**. FIG. **3***c* illustrates the resultant phosphosilicate glass (PSG) layer **40** on the top mold member **20** and the PSG layer **42** on the bottom mold member **30**. The phosphosilicate glass is then reflowed (Step G). Approximately 0.5 microns of undoped polysilicon is then deposited (Step M) on the bottom mold member **30**. The bottom mold member **30** is then subject to wet oxidation (Step V) to form an oxide of approximately 1 micron. The resultant silicon dioxide layer **44** is illustrated in FIG. **3***d*. Approximately 0.5 microns of undoped polysilicon is then deposited (Step M) on the bottom mold member **30** once again. The bottom mold member **30** is then subject to wet oxidation (Step V) to form an oxide of approximately 1 micron. The resultant silicon dioxide layer **46** is illustrated in FIG. **3***e*.

The top mold member **20** is then aligned with the bottom mold member **30**. Standard techniques, including microscopic viewing techniques and alignment marks may be used in this step. The mold members are then pressure bonded together to produce the device of FIG. **3***f*.

At this point, the needle can be formed by depositing a conformal substance into the mold. In particular, the conformal substance is passed through the deposition apertures into the enclosed, elongated needle trench. For example, approximately 0.3 microns of undoped polysilicon (Step M) may be deposited. Thereafter, a nitrogen anneal (Step O) is performed. The foregoing polysilicon and nitrogen anneal steps are repeated until the desired thickness of polysilicon is achieved. Six to fifteen microns of polysilicon is typical, depending on the strength and stiffness requirements. The resultant device is illustrated in FIG. **3***g*. In particular, the figure shows a polysilicon layer **50**. The polysilicon layer **60** within the trench **34** defines a needle. FIG. **3***h* provides a perspective view of the device at this processing juncture.

An anisotropic polysilicon etch on the top side of the wafer sandwich of FIGS. **3***g* and **3***h* is then performed (Step N). The polysilicon thickness and a 75% over-etch are preferably performed. This operation results in the device of FIG. **3***i*. An anisotropic polysilicon etch on the bottom side of the wafer sandwich is then performed. The polysilicon thickness and a 25% over-etch are preferably performed, resulting in the device of FIG. **3***j*.

The sacrificial phosphosilicate glass layers **42** and **44** are then removed (Step S). The top mold member **20** and the bottom mold member **30** are then separated, and the resultant needle is released. FIG. **3***k* is a side view of the separated top mold member **20**, bottom mold member **30**, and released needle **60**. FIG. **3***l* is a perspective view of the separated top mold member **20**, bottom mold member **30**, and released needle **60**.

The released needle and mold members are then rinsed in DI water. The needle may be used at this point and the mold members may be re-used.

FIG. **4** is a perspective view of a needle **70** constructed in accordance with the disclosed processing steps. The needle

70 includes a fluid input port **72** and a set of fluid outlet ports **74**. The operations described in relation to FIG. **1** are altered to produce additional deposition apertures in the top mold member so that the additional fluid outlet ports **74** may be provided. Observe that each deposition aperture in the top mold member results in a port in the resultant needle.

FIG. **5** is a perspective view of another needle **80** constructed in accordance with the processing steps of the invention. The needle **80** includes removal inhibiting barbs **82** and insertion limiting barbs **84**. The operations described in relation to FIG. **2** are altered to provide a bottom mold member with the configuration corresponding to the barbs **82** and **84**.

FIG. **6** is a perspective view of another needle **90** constructed in accordance with the processing steps of the invention. The needle **90** includes strength enhancement features. In accordance with the invention, strength enhancement features may be in the form of ribs, coatings, or bands. FIG. **6** illustrates internal ribs **92** for strength enhancement. FIG. **7** is an enlarged view of the region **94** of FIG. **6**. FIG. **7** provides a more detailed view of the internal ribs **92**. The operations described in relation to FIG. **2** are altered to provide the bottom mold member with ribs.

FIG. **8** is a perspective view of a dual prong needle **100** constructed in accordance with the processing steps of the invention. The needle **100** includes a first prong **102** and a second prong **104** joined at a hub **106**. The operations described in relation to FIG. **2** are altered to provide the bottom mold member with the a trench to form the first prong **102** and a trench to form the second prong **104**.

FIG. **9** is a perspective view of yet another needle **110** constructed in accordance with the processing steps of the invention. The needle **110** includes circuitry **112**. The circuitry that may be incorporated into a needle of the invention includes electrodes, amplification circuitry, pumps, and biological sensors. Since the needle **110** is formed of polysilicon, standard processing techniques may be used to add the circuitry **112** to the needle **110**.

Those skilled in the art will appreciate that various other geometries may be constructed in accordance with the disclosed processing steps. For example, multiple fluid cannulas, pumps, heaters, electrodes, and amplification circuitry may readily be incorporated into the needles of the invention. The simple needle shown in the figures can have any or all of these features added to it by easy modifications of the etch masks of the molds. To fabricate features or components of the needle such as heaters, electrodes, and amplification circuitry, the release etch must be timed such that the molds are separated, but the needles are still embedded in the mold cavities of the bottom mold wafer. This partial release process step may be aided by using only silicon dioxide as the release layer around the needle, but still using PSG for the wafer to wafer bonding. This change will aid partial release because PSG is etched much faster than silicon dioxide. After this step, further processing can be done to the bottom mold wafer alone to put the features or components mentioned above on the needles. Heaters and/or electrodes can be fabricated by a metal or doped polysilicon deposition and subsequent masking and etching. Amplification circuitry can be added using a CMOS, NMOS, bipolar or FET process. All features that are made of materials other than silicon may be damaged by the concentrated HF release etch, so they should be protected by a layer of polysilicon or other material that is resistant to HF.

Needles of the invention have been fabricated on a 100 mm wafer. In particular, over a 1000 needles with lengths of 3 and 6 mm have been fabricated with a 100 mm wafer. Needles up to two inches long may be fabricated in accordance with the invention. For such an embodiment, the deposition apertures in the top mold member **20** must be enlarged.

The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the invention. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the invention. In other instances, well known circuits and devices are shown in block diagram form in order to avoid unnecessary distraction from the underlying invention. Thus, the foregoing descriptions of specific embodiments of the present invention are presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, obviously many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following Claims and their equivalents.

We claim:

1. A two-piece mold for use in conformally constructing a needle, comprising:

a top mold member having a deposition aperture; and

a bottom mold member connected to said top mold member, said bottom mold member and said top mold member defining an enclosed, elongated needle trench with said deposition aperture,

wherein said deposition aperture is configured to allow a conformal substance to enter said enclosed, elongated needle trench such that said conformal substance is deposited within said enclosed, elongated needle trench to form a needle, except at said deposition aperture where a fluid port aperture of a needle results.

2. The two-piece mold of claim **1** wherein said bottom mold member defines an elongated needle trench.

3. A two-piece mold for use in conformally constructing a needle, comprising:

a first mold member configured to define a first portion of an elongated needle trench; and

a second mold member configured to define a second portion of said elongated needle trench and to connect to said first mold member to define said elongated needle trench, wherein said second mold member comprises a deposition aperture configured to allow a conformal substance to enter said elongated needle trench such that said conformal substance is deposited within said elongated needle trench to form a needle, except at said deposition aperture where a fluid port aperture of the needle results.

4. The two-piece mold of claim **3**, wherein said first mold member and said second mold member each comprise a semiconductor substrate.

5. The two-piece mold of claim **4**, further comprising a sacrificial layer disposed between the first mold member and the second mold member.

6. The two-piece mold of claim **5**, wherein said first mold member and said second mold member are configured to be separated and to release the needle when said sacrificial layer is etched.

7. A two-piece mold for use in conformally constructing a needle, comprising:

a first mold member configured to at least partially define an elongated needle trench; and

a second mold member configured to connect to said first mold member, wherein said first mold member and second mold member are configured to jointly define the elongated needle trench as an enclosed, elongated needle trench, and wherein said second mold member comprises a deposition aperture configured to allow a conformal substance to enter said elongated needle trench such that said conformal substance is deposited within said elongated needle trench to form a needle, except at said deposition aperture where a fluid port aperture of the needle results.

8. The two-piece mold of claim **7**, wherein said first mold member and said second mold member each comprise a semiconductor substrate.

9. The two-piece mold of claim **8**, further comprising a sacrificial layer disposed between the first mold member and the second mold member.

10. The two-piece mold of claim **9**, wherein said first mold member and said second mold member are configured to be separated and to release the needle when said sacrificial layer is etched.

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